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Structure of arboreal and herbaceous strata in a neotropical seasonally flooded monodominant savanna of *Tabebuia aurea*

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Abstract

Large areas in the Pantanal wetland are covered by monodominant formations, e.g. typical landscapes with local names such as "paratudal", dominated by *T. aurea*. Studies on structure of these formations generally include only woody strata, consequently the species richness registered is usually low due to the absence of the 'ground layer' of herbaceous and others low species. We recorded 13 species, 12 genera and 11 families for the arboreal stratum. Considering arboreal flora without the dominant (*T. aurea*) individuals showed great establishment in relation to the flood level between 35 – 45 cm while the individuals of the dominant species of 30 – 45 cm. The diameter distribution revealed that the population of *T. aurea* did not show the reverse J curve, the usual pattern for species in constant regeneration, also evidenced in inconstant Licourt quotient, indicating an episodic recruitment that could lead to future changes in structure. In the herbaceous strata we recorded 78 species, included in 62 genera and 27 families. Using plots method we sampled 46 species, 40 genera and 22 families, while in line interception we found 65 species distributed in 57 genera and 26 families. The floristic similarity of Sørensen between both methods was 59.4%, with 33 species in common, and the method of line interception was more efficient in detecting richness, with 35% more species found in the same time. According to the methods of plots and line interception applied on the woody stratum, our results gave similar detailed information on the structure of this type of savanna, and in spite of being monodominant it shows high species richness when the herbaceous stratum is taken into account. Plots and line interception methods showed similar results for the woody stratum and high species richness of the herbaceous stratum.

Keywords: line interception method, plot method, wetland, paratudal, pantanal.

Estrutura do estrato arbóreo e herbáceo em uma savana neotropical monodominante sazonalmente inundada de *Tabebuia aurea*

Resumo

Amplas áreas no Pantanal são cobertas por formações monodominantes, tipicamente com nomes locais como "paratudal" dominado por *Tabebuia aurea*. Estudos na estrutura dessas formações geralmente incluem somente estrato arbóreo, consequentemente, a riqueza de espécies detectada geralmente é baixa devido à ausência do "estrato terrestre" das herbáceas e outras poucas espécies. Nós registramos 13 espécies, 12 gêneros e 11 famílias para o estrato arbóreo. Considerando a flora arbórea sem a espécie dominante (*T. aurea*) apresentaram um ótimo de estabelecimento em relação ao nível de inundação entre 35 – 45cm, enquanto os indíviduos da espécie dominante de 30 – 45cm. A distribuição diamétrica revelou que a população de *T. aurea* não apresentou o J reverso, o modelo usual para espécies em constante regeneração, também evidenciado pela não constante no quoeficiente de Licourt. Indicando episódio de recrutamento que poderia levar a futuras mudanças na estrutura. Para o estrato herbáceo geral registramos 78 espécies, incluindo 68 gêneros e 27 famílias. Usando o método de parcelas amostramos 46 espécies, 40 gêneros e 22 famílias, enquanto na interseção na linha nós encontramos 65 espécies distribuídas em 57 gêneros e 26 famílias. A similaridade florísitca de Sørensen entre ambos métodos foi de 59,4%, com 33 espécies em comum, e o método de interseção na linha foi mais eficiente na detecção da riqueza, 35% das espécies foram encontradas no mesmo tempo. De acordo com os métodos de parcelas e interseção na linha aplicado no estrato arbóreo, os nossos resultados deram uma semelhante informação detalhada na estrutura deste tipo de savana, e que apesar de ser monodominante mostrou alta riqueza de espécies quando o estrato herbáceo é levado em conta. Os métodos de parcelas e interseção na linha mostraram resultados similares para o estrato arbóreo e alta riqueza de espécies do estrato herbáceo.

Palavras-chave: método de interseção na linha, método de parcela, planície inundável, paratudal, pantanal.

1. Introduction

A forest is considered monodominant when more than 50% of the individuals or of its basal area belong to a single species (Connell and Lowman, 1989; Hart et al., 1989). In general, such forests are in sharp contrast to other tropical forests where species diversity is much greater and they represent one of the most intriguing enigmas of tropical ecology (Schluter and Ricklefs, 1993). According to Richards (1952), extensive vegetation formations dominated by a single or a few species are present in several tropical regions and can cover hundreds of square kilometres, often occurring adjacent to other forest types of higher diversity.

Such monodominant formations have been the subject of a few studies, in which subjects such as floristic composition, structure, soils, population dynamics were studied. Amongst these, two areas are particularly notable: forest dominated by *Brosimum rubescens* Taub. in the state of Mato Grosso (Marimon et al., 2001a, b) and forest dominated by *Peltogyne gracilipes* Ducke on the Island of Maracá, in Roraima (Milliken and Ratter, 1989, 1998; Nascimento and Proctor, 1994; 1997a, b; Villela and Proctor, 1999).

Wetland monodominant formations are particularly important in the Brazilian Pantanal and cover large areas forming typical landscapes that receive local names such as "canjiqueiral" (dominated by *Byrsonima cydoniifolia* A. Juss.), "cambarazal" (of *Vochysia divergens* Pohl), "carandazal" (of *Copernicia alba* Morong ex Morong and Britton), "paratudal" (of *Tabebuia aurea* (Silva Manso) Benth. and Hook.), and others (Pott and Pott, 1994). Most of these formations are seasonally flooded savannas. The main studies of monodominant formations in the Pantanal are (i) of *V. divergens* forest in the sub-region of Poconé (Nascimento and Cunha, 1989; Arieira and Cunha, 2006); (ii) of *C. alba* palm savanna in the sub-regions of Miranda and Nabileque, Mato Grosso do Sul (Amador et al., 2012); and (iii) of the arboreal stratum of *T. aurea* in the sub-region of Miranda (Ribeiro and Brown, 2002; Soares and Oliveira, 2009).

However, studies of the structure of these monodominant formations usually include only the tree and shrub strata, and use the plot method, e.g. that of *V. divergens* by Nascimento and Cunha (1989), and Arieira and Cunha (2006), and *T. aurea* savanna by Ribeiro and Brown (2002) and Soares and Oliveira (2009). As a consequence, the species richness found is usually very low. However, in a study on *C. alba* savanna Amador et al. (2012) demonstrated that it is species-rich when the herbaceous stratum is included. As herbs constitute the major part of the floristic diversity of the Pantanal (Pott and Pott, 1999; Schessl, 1999), it is possible that all the monodominant formations of the Pantanal are in fact species-rich. Hence, for a more complete evaluation of this vegetation, it is necessary to have more comprehensive methods to describe both strata.

Two main methods are used to evaluate herbaceous formations in Brazil: the line interception method (Canfield, 1941, 1950; Brower and Zar, 1977), used by Munhoz and Felfili (2006), and the plot method with cover percentages (Brower and Zar, 1977) used, for example, by Prado et al. (1994) and Rebelatto and Cunha (2005). The method of plots with percentage cover can also be used for study of woody vegetation, supplying a good description where both strata are important (Damasceno-Junior and Pott, 2011). However, comparative evaluations of these methods have not yet been used for monodominant formations of the Pantanal.

Thus, following the precept of study in monodominant formations, the objective of this study is to evaluate the phytosociological structure of the tree and herbaceous stratum monodominant formation of *T. aurea* ("paratudal") in the Pantanal wetlands, directing the following questions. (i) Would flood be a factor influencing structure, richness and diversity of species in "paratudal" for both strata? (ii) Can the combination of the methods of the intersection lines and plots show variation in species richness?

2. Material and Methods

2.1. Study area

The Pantanal sub-region of Miranda is located within the following boundaries: to the North, the sub-region of Abobral; to the South, the Chaco woodlands of the municipality of Porto Murtinho; to the East, the sub-region of Aquidauana; and to the West, the Bodoquena highlands and the sub-region of Nabileque (Figure 1). It covers an area of 5,000 km^2, of savanna (Cerrado), forest and grassland vegetation including a strong concentration of *Copernicia alba* palm savanna and especially *Tabebuia aurea* savanna (Brasil, 1982; Loureiro et al., 1982; Amaral, 1987).

Tabebuia aurea forms a park savanna vegetation (Loureiro et al., 1982), and, in spite of occupying large

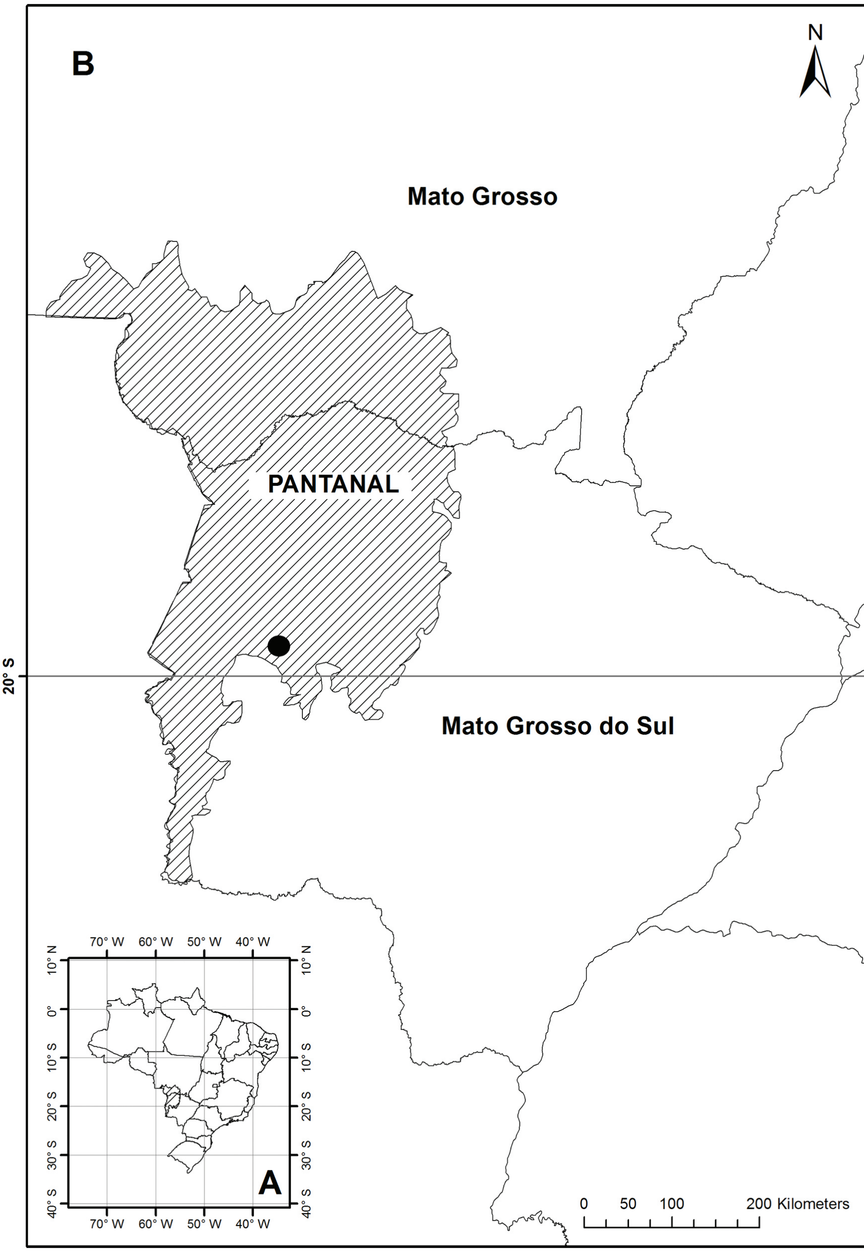

Figure 1. Location of the Pantanal in Brazil (**A**), and the detail of the Pantanal wetland (**B**). The circule black indicates the the study area, ranch São Bento, close to the Pantanal research station of UFMS, on the right margin of the river Miranda, at Passo do Lontra, municipality of Corumbá, Mato Grosso do Sul state, Brazil.

areas, it is almost restricted to the Miranda and Nabileque sub-regions of the Pantanal, associated with slightly alkaline waters and sediments (Pott and Pott, 1994). It shows continuous areas into the Paraguayan and Bolivian wetlands; the species also occurs sparsely in the sub-regions of the Nhecolândia and Poconé (Pott and Pott, 1994). The dominant species (*T. aurea*) usually occurs on very compact clay soil, where there are so called mounds or "murundus" (Ribeiro and Brown, 2002; Soares and Oliveira, 2009). It has seasonally flood plain areas with grasses and other herbs covered by water of variable depth in the flood period.

The area has loamy-clay and sandy soils, with a strong predominance of the former (Silva et al., 2000). The climate is type *Aw* of Köppen (1948), with annual rainfall around 1,100 mm. Our study was carried out at São Bento ranch (19°30'S, 57°04'W) close to the Pantanal Research Station of the Federal University of Mato Grosso do Sul (UFMS), on the right bank of the Miranda river, at Passo do Lontra, Corumbá, Mato Grosso do Sul.

2.2. Methods

We used two methods for the phytosociological analyses (as following by Damasceno-Junior and Pott (2011)) (i) the plot method, where large plots were used for arboreal and smaller nested plots for herbaceous strata, and (ii) in addition the line interception for the latter.

The trees were sampled using ten plots of 0.15 ha (50×30 m), totalling 1.5 ha. These were randomly distributed in each of the *T. aurea* stands. The diameter of all trees with dbh ≥ 3.18 cm was measured as was that of their larger branches. Height was also estimated using a 2 m stick. The height of the water mark of the last flood on tree-trunks was also measured. In each plot 20 nested subplots (totalling 50 m^2) were placed in random directions approximately 10m apart. In each plot the percentage cover per species was estimated visually; the same was done for bare ground and with that covered by dead material.

The second method was that of line interception (Canfield, 1941, 1950), for determination of the composition and linear cover of the ground species. Eight lines of 50 m were placed in random directions, inside and outside the plots of trees, with each line subdivided into sampling units of 1m, giving a total of 400 m. The method consists of recording the position and the cover area of each species, that is, the length which each inventoried species occupies per sample along the lines and is then divided by the total length of the species under the line, thus estimating the proportion of the area covered by that species. The sum of the horizontal projection of each species in all sampling units corresponds to the value of absolute lineal cover of the species in the area. The relative cover (RC) was determined by dividing the AC of each species by the sum of the AC of all multiplied by 100. The record of occurrence of each species in sampling units was used to calculate frequency. In both methods a concept of importance value (IV) for herbaceous vegetation was used; the concept was adapted where the relative frequency and RC were added to form the IV for which the maximum is 200 (Damasceno-Junior and Pott, 2011). We recorded bare ground and/or dead matter together with the vegetation analysis.

Individuals of *T. aurea* were distributed in diameter classes with optimal interval class (IC=6.0) calculated by the formulae of Spiegel (1976). Where, IC = A/NC; NC = 1+3,3 logN; A = range diameters; NC = number of classes e N = number of individuals.

The Licourt quotient "q", dividing each diameter class by the previous one (Meyer, 1952), was calculated allowing inferences about recruitment and mortality to be made. A constant relation between classes indicates that recruitment and mortality rates are balanced (Nascimento et al., 2004).

Species were identified in the field, using the nomenclature of APG III (2009), and when this was not possible, herbarium specimens were collected and later identified by specialists at the Universidade Federal de Mato Grosso do Sul (UFMS), Campo Grande campus.

The tree stratum was analysed using the program Mata Nativa 2 (Cientec, 2009), to calculate the phytosociological parameters. In both methods, Shannon's diversity (H') and equability index (E) for the herbaceous vegetation were calculated as recommended by Munhoz and Felfili (2006) using the cover per species and not the number of individuals.

3. Results

3.1. Arboreal and herbaceous strata

A total of 88 species belonging to 72 genera and 30 families were recorded (Table 1). The most represented families were Poaceae with 18 species (20.2% of the total species), Fabaceae with 12 (13.5%), Malvaceae with 8 (9.0%), Rubiaceae with 5 (5.6%), Cyperaceae with 4 (4.5%), and Alismataceae, Asteraceae, Euphorbiaceae, Onagraceae and Verbenaceae each with 3 species (3.4%) (Table 1).

In the 1.5 ha sampled for tree stratum of *T. aurea* savanna, we recorded 448 individuals of 13 species from 12 genera and 11 families. The most represented families were Bignoniaceae and Fabaceae with two species each and the other families occurred only once. *T. aurea* had the highest IV, followed by *B. cydoniifolia* (Table 2). The diversity index (H') was 0.84, with an evenness (E) of 0.33.

Judging by the watermarks on the trunks, 30-45 cm of flooding was the commonest level for *T. aurea*, the dominant species, while other species showed 35-45 cm (Figure 2). The diameter distribution did not show the reverse "J" pattern as expected for a population in constant regeneration as in the case of the dominant species, *T. aurea* (Figure 3).

The families with the largest number of species in the herbaceous stratum were Poaceae (18), Fabaceae (10), Malvaceae (8), Cyperaceae and Rubiaceae with 4 species each, totalling 53.7% of the recorded species. In the plots we sampled 46 species, 40 genera and 22 families. Line interception gave 65 species distributed in 57 genera and 26 families. Index of species Shannon diversity (H') and equability (E) were respectively 2.67 nats/individuals and 0.68 for the method of plots, and 2.25 nats/individuals and 0.53 for the method of the line interception.

The phytosociological survey of the herbaceous stratum showed 78 species, included in 62 genera and 27 families (Table 3). *Sebastiania hispida* and *Andropogon hypogynus* showed the highest importance values (IV) in both methods employed (Figure 4). The class bare area (bare ground and/or dead matter) had the largest IV in both methods (29.0% for plots and 48.4% for line interception), the other categories were species showing differences in cover and IV (Table 3).

3.2. Comparison of methods

The Sørensen floristic similarity comparing the results of both methods was 59.4%, with 33 species in common (Table 3). Despite this, both methods showed lower values of Shannon diversity index (H') (2.25 line and 2.67 plot) for species and equability (E) (0.68 line and 0.53 plot), the diversity detected by line interception was more efficient, with 35% more species recorded than for the plots (Table 3).

Table 1. List of species recorded in a tropical floodable *Tabebuia aurea* monodominant savanna, sub-region of Miranda, Pantanal, MS, Brazil. And sampling method: A - tree plot method; B - herbaceous plot method; C - line interception method for herbaceous species.

Species	Methodology
ALISMATACEAE	
Echinodorus grandiflorus (Cham. & Schltdl.) Micheli	C
Echinodorus paniculatus Micheli	B, C
Echinodorus teretoscapus Haynes & Holm-Niels	B
AMARANTHACEAE	
Pfaffia glomerata (Spreng.) Pedersen	B, C
ANNONACEAE	
Annona nutans (R.E.Fr.) R.E.Fr.	C
APOCYNACEAE	
Prestonia coalita (Vell.) Woodson	C
Thevetia bicornuta Müll. Arg.	B, C
ARECACEAE	
Copernicia alba Morong	A, B
ASTERACEAE	
Aspilia latissima Malme	B, C
Eupatorium arnottianum Griseb.	B, C
Sphagneticola brachycarpa Baker	B, C
BIGNONIACEAE	
Handroanthus heptaphyllus (Vell.) Mattos	A
Tabebuia aurea (Silva Manso) Benth. & Hook. f. ex S. Moore	A, B, C
COMMELINACEAE	
Commelina erecta L.	B
Commelina schomburgkiana Klotzsch	C
Commelina sp.	B
CONVOLVULACEAE	
Aniseia cernua Choisy	C
Merremia umbellata (L.) Hallier f.	B, C
CHRYSOBALANACEAE	
Licania parvifolia Huber	A
CYPERACEAE	
Cyperus haspan L.	B, C
Eleocharis elegans (Kunth) Roem. & Schult.	C
Eleocharis interstincta (Vahl) Roem. & Schult.	B, C
Scleria microcarpa Nees	B, C
ERYTHROXYLACEAE	
Erythroxylum anguifugum Mart.	A, C
EUPHORBIACEAE	
Sapium haematospermum Müll. Arg.	C
Sapium longifolium (Müll. Arg.) Huber	A, B, C
Sebastiania hispida (Mart.) Pax ex Engl.	B, C
FABACEAE	
Albizia inundata (Mart.) Barneby & Grimes	A

Table 1. (be continued).

Species	Methodology
Aeschynomene rudis Benth.	C
Aeschynomene sensitiva Sw.	C
Aeschynomene fluminensis Vell.	B
Bauhinia bauhinioides (Mart.) J.F. Macbr.	C
Camptosema paraguariense (Chodat & Hassl.) Hassl.	B, C
Camptosema sp	B
Indigofera lespedezioides Kunth	B, C
Inga vera Willd.	A
Mimosa pigra L.	B
Stylosanthes capitata Vogel	C
Vigna longifolia (Benth.) Verdc.	C
LAMIACEAE	
Hyptis brevipes Poit.	B
LYTHRACEAE	
Adenaria floribunda Kunth	C
MALPIGHIACEAE	
Byrsonima cydoniifolia A. Juss.	A, B, C
MALVACEAE	
Byttneria dentata Pohl	B, C
Corchorus argutus Kunth	C
Helicteres guazumifolia H. B. K.	C
Melochia arenosa Benth.	C
Melochia parvifolia H. B. K.	C
Melochia simplex A. St.-Hil.	B, C
Pavonia angustifolia Benth.	C
Sida cerradoensis Krap.	B
MYRTACEAE	
Eugenia florida DC.	A
Psidium kennedyanum Morong	B, C
ONAGRACEAE	
Ludwigia lagunae (Morong) Hara	B
Ludwigia octovalvis (Jacq.) P.H. Raven	B, C
Ludwigia tomentosa (Camb.) Hara.	B
PHYLLANTHACEAE	
Phyllanthus amarus Schumach. & Thonn.	B
Phyllanthus stipulatus (Raf.) G.L. Webster	C
POACEAE	
Andropogon bicornis L.	B, C
Andropogon hypogynus Hack.	B, C
Axonopus leptostachyus (Flüggé) Hitchc.	C
Eriochloa punctata (L.) Desv. ex Ham.	C
Hymenachne amplexicaulis (Rudge) Nees	B
Ichnanthus procurrens (Nees ex Trin.) Swallen	B, C
Imperata tenuis Hack.	B, C

Table 1. (be continued).

Species	Methodology
Leersia hexandra Sw.	C
Panicum dichotomiflorum Michx.	C
Paspalum hydrophilum Henrard	C
Paspalum laxum Lam.	C
Paspalum pontanalis Swallen	B, C
Pennisetum nervosum (Nees) Trin.	C
Reimarochloa acuta (Flüggé) Hitchc.	B, C
Schizachyrium microstachyum (Desv. ex Ham.) Roseng., B.R. Arrill. & Izag.	B, C
Setaria parviflora (Poir.) Kerguélen	B, C
Sorghastrum setosum (Griseb.) Hitchc.	B, C
Steinchisma laxum (Sw.) Zuloaga	B, C
PONTEDERIACEAE	
Pontederia cordata L.	B
Pontederia subovata (Seub.) Lowden	B, C
RUBIACEAE	
Borreria quadrifaria E.L. Cabral	B, C
Genipa americana L.	A
Psychotria carthagenensis Jacq.	C
Spermacoceodes glabrum (Michx.) Kuntze	C
Staelia thymoides Cham. & Schltdl.	C
RUTACEAE	
Zanthoxylum rigidum Humb. & Bonpl. ex Willd	A
SALICACEAE	
Banara arguta Briq.	C
SAPINDACEAE	
Paullinia pinnata L.	B, C
URTICACEAE	
Cecropia pachystachya Trec.	A
VERBENACEAE	
Lantana camara L.	C
Lantana canescens Kunth. L.	B
Lippia alba (Mill.) N.E. Br.	B, C
VITACEAE	
Cissus spinosa Cambess.	B, C

4. Discussion

4.1. Arboreal stratum

Our study recorded more species in the arboreal stratum (13) than in the surveys by Soares and Oliveira (2009) in three *T. aurea* areas in the Pantanal sub-region of Miranda, where six recorded tree species occurred, all of them also found in our study (*T. aurea, B. cydoniifolia, Erythroxylon anguifugum, Inga vera, Handroanthus heptaphyllus, Zanthoxylum rigidum*) (Table 2). Such low diversity of woody species is reported for other monodominant formations (Nascimento and Cunha 1989; Arieira and Cunha 2006; Amador et al., 2012), demonstrating that the higher the water level and the longer its duration, the smaller the number of tolerant species. Damasceno-Junior et al. (2005), Amorim and Batalha (2006), Carvalho et al. (2006), Silva and Batalha (2008) and Cianciaruso and Batalha (2009) discuss water saturation of the soil as a selective force for tree species, limiting diversity by acting as an environmental filter against intolerant species. However, tree species conditioned to flooding and showing tolerance to such stress were recorded (Pott and Pott 1994; Damasceno-Junior et al., 2005; Pott et al., 2011).

Of the case species *T. aurea* dominates compared to the other species recorded in the Paratudal, showing an advantage because of the flood pulse. *T. aurea* is the species most tolerant of such stress and thus dominates in wetter conditions (Pott and Pott, 1994; Damasceno-Junior et al., 2005; Pott and Pott, 1999). As described by Soares and Oliveira (2009), the growth of *T. aurea* on the mounds (murundus) is probably a factor that allows seedling survival in times of flood, when these mounds protect the young individuals from submersion.

The advantage afforded is reflected in the importance value as well as dominance of *T. aurea*, a factor referred to by several authors, who mention it as a species associated with mounds, i.e. small elevations on the plain (miniature islands), where *T. aurea* avoid floods. However, in our area *T. aurea* occur not only on mounds, but also more rarely on the lower ground in between them, although there is an indication that *T. aurea* cannot survive below the floodline (Pott and Pott, 1994; Ribeiro and Brown, 2002). The mound/*T. aurea* association tends to be more frequent where duration and level of flood are higher, such as in the case of the Paratudal under influence of the Paraguay river flood, providing the trees higher probability of survival to grow almost exclusively on the mounds. Silva Júnior and Felfili (1996) add that these islands or mounds have drainage conditions and determine good soil aeration favouring the propagation of tree species.

In the Licourt quotient, where "q" is not constant, as in the case of the values of our study, there is a discrepancy between rates of mortality and recruitment that characterise changes in forest structure (Felfili et al., 1998). However, it is probable that, according to Felfili (1997), species require a broad spatial and temporal scale to achieve balance between these events. Although establishment of individuals under varying conditions may cause differences in the distribution pattern of tree diameters. Such differences could be in variation in flood conditions on anthropic activity such as burning and grazing.

4.2. Herbaceous stratum

The floristic richness of Poaceae and their dominance cover in of many habitats in the Pantanal are well known, and they are very important as natural forage. The Poaceae, Malvaceae, Rubiaceae and Cyperaceae are also abundant in the Pantanal, the last particularly in more humid areas. More severe flooding limits the numbers of herbaceous species but under such conditions semi-aquatic and aquatic

Table 2. Phytosociological parameters of species observed in a tropical floodable *Tabebuia aurea* monodominant savanna, sub-region of Miranda, Pantanal, MS, Brazil. N = number of individuals; BA = basal area; AD = absolute density; RD = relative density; AF = absolute frequency, RF = relative frequency; ADo = absolute dominance; RDo = relative dominance; CV = coverage value, CV% = coverage value percentage, IV = importance value, IV% = importance value percentage.

Scientific Name	N	BA	AD	RD	AF	RF	ADo	RDo	CV	CV (%)	IV	IV (%)
Tabebuia aurea	346	11.27	231	77.23	100	25.64	7.52	75.23	152.47	76.23	178.11	59.37
Byrsonima cydoniifolia	69	2.43	46	15.40	70	17.95	1.63	16.27	31.67	15.84	49.62	16.54
Erythroxylum anguifugum	5	0.61	3	1.12	30	7.69	0.41	4.10	5.22	2.61	12.91	4.30
Zanthoxylum rigidum	7	0.04	5	1.56	40	10.26	0.03	0.29	1.85	0.93	12.11	4.04
Genipa americana	3	0.05	2	0.67	30	7.69	0.03	0.32	0.99	0.50	8.69	2.89
Copernicia alba	3	0.19	2	0.67	20	5.13	0.12	1.24	1.91	0.95	7.04	2.35
Inga vera	2	0.20	1	0.45	20	5.13	0.13	1.31	1.75	0.88	6.88	2.29
Handrohanthus heptaphyllus	3	0.12	2	0.67	20	5.13	0.08	0.80	1.47	0.73	6.59	2.20
Sapium longifolium	5	0.01	3	1.12	20	5.13	0.01	0.08	1.19	0.60	6.32	2.11
Eugenia florida	2	0.01	1	0.45	10	2.56	0.01	0.04	0.49	0.24	3.05	1.02
Licania parvifolia	1	0.04	1	0.22	10	2.56	0.03	0.28	0.51	0.25	3.07	1.02
Albizia inundata	1	0.00	1	0.22	10	2.56	0.01	0.03	0.25	0.12	2.81	0.94
Cecropia pachystachya	1	0.00	1	0.22	10	2.56	0.01	0.01	0.23	0.12	2.80	0.93
Total	448	15	299	100	390	100	10	100	200	100	300	100

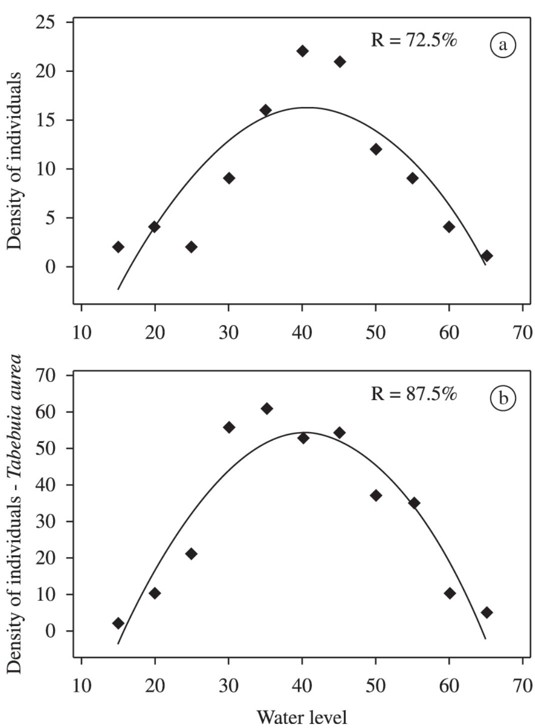

Figure 2. **(a)** Representation of the relationship of population density of tree species without *Tabebuia aurea* with the height of the water mark (cm) (p = 0.002), and **(b)** relationship of population density of *Tabebuia aurea* with the height of the water mark (cm) (p < 0.001), in a tropical floodable *Tabebuia aurea* monodominant savanna, sub-region of Miranda, Pantanal, Mato Grosso do Sul state, Brazil.

perennials appear such as *Echinodorus grandiflorus*, *E. paniculatus*, *E. teretoscapus*, *Ludwigia lagunae*, *L. octovalvis*, *L. tomentosa*, *Pontederia cordata*, *P. subovata* (Pott and Pott, 2000). Whereas *Axonopus leptostachyus, Paspalum laxum, Reimarochloa acuta, Setaria parvilfora* are indicators of dry periods (Pott and Pott, 1994; Schessl, 1999).

In the area analysed, as in other areas subject to flooding, the effect is to limit the number of both woody and herbaceous species in the environment (Rebellato and Cunha, 2005); clearly this varies with the duration severity and frequency of flooding (Scremin-Dias et al. 2011).

This conditioning for herbaceous diversity values were below those recorded for the Pantanal flood areas of Poconé for both periods (flood 4.01-3.29 drought) (Rebellato and Cunha, 2005). And there was also a lower value from Carandazal of the sub-region of Miranda (1.15) and a higher one for Carandazal of the sub-region of Nabileque (0.33) (Amador et al., 2012). These differences in the compared diversity values, are associated to environmental conditions, such as the lower value recorded for Carandazal from Nabileque. The reason is that areas under inundation of the Paraguay River are subject to more strict conditions (Amador et al., 2012). Schessl (1999) observed that in the more flooded Pantanal environment of Poconé, there is a strong variation in the coverage and composition of species promoted by hydric seasonality. Therefore, depending on the intensity and duration of flooding, different responses of ground layer characterise communities in relation to richness and diversity, as observed in the Paratudal.

Table 3. Phytosociological parameters of herbaceous species found in a tropical floodable *Tabebuia aurea* monodominant savanna. sub-region of Miranda. Pantanal. MS. Brazil. Line interception and Plots methods. RC = Relative Cover; RF = relative frequency; VIh = importance value for herbaceous plants.

Species	Methods					
	Line			Plot		
	CR	FR	VIh	CR	FR	VIh
Adenaria floribunda	0.08	0.12	0.24			
Aeschynomene fluminensis				0.22	0.37	0.59
Aeschynomene rudis	0.01	0.06	0.12			
Aeschynomene sensitiva	0.01	0.06	0.12			
Andropogon bicornis	8.55	4.11	8.23	2.56	1.98	4.55
Andropogon hypogynus	13.25	7.81	15.62	16.92	9.91	26.90
Aniseia cernua	0.25	0.78	1.55			
Annona nutans	0.01	0.06	0.12			
Aspilia latissima	0.04	0.18	0.36	0.04	0.12	0.17
Axonopus leptostachyus	0.68	0.83	1.67			
Banara arguta	0.41	0.30	0.60			
Bauhinia bauhinioides	0.09	0.12	0.24			
Borreria quadrifaria	0.01	0.06	0.12	4.18	6.07	10.27
Byrsonima cydoniifolia	0.89	0.42	0.83	0.84	0.37	1.21
Byttneria dentata	1.07	1.49	2.98	0.57	1.24	1.82
Camptosema paraguariense	0.08	0.06	0.12	0.09	0.25	0.34
Cissus spinosa	0.01	0.06	0.12	0.73	0.74	1.47
Commelina erecta				1.05	0.62	0.86
Commelina schomburgkiana	0.01	0.06	0.12			
Corchorus argutus	0.04	0.24	0.48			
Cyperus haspan	0.12	0.42	0.83			
Echinodorus grandiflorus	0.19	0.36	0.72			
Echinodorus paniculatus	0.16	0.60	1.19	2.08	2.85	4.93
Echinodorus teretoscapus				2.21	3.10	5.31
Eleocharis elegans	0.08	0.36	0.72			
Eleocharis interstincta	0.10	0.12	0.24	0.44	0.74	1.19
Eriochloa punctata	0.20	0.42	0.83			
Erythroxylum anguifugum	0.02	0.12	0.24			
Eupatorium arnottianum	0.46	1.13	2.27	0.53	0.74	1.28
Helicteres guazumifolia	2.48	1.67	3.34			
Hyptis brevipes				0.02	0.12	0.15
Ichnanthus procurrens	0.09	0.18	0.36	0.35	0.37	0.73
Imperata tenuis	0.09	0.18	0.36	4.79	1.98	6.79
Indigofera lespedezioides	0.15	0.18	0.36	0.33	0.62	0.95
Lantana camara	0.02	0.06	0.12			
Lantana canescens				0.02	0.12	0.15
Leersia hexandra	0.33	0.72	1.43			
Lippia alba	3.09	9.24	18.49	2.91	0.12	3.05
Ludwigia lagunae				1.72	0.25	1.98

Within the herbaceous species that best featured the structure phytosociology for both methodologies were *Sebastiania hispida* which is characterised as weedy and an indicator of disturbance and fire (Pott and Pott, 1994), and *Andropogon hypogynus* cited as a dominant grass species in the Miranda sub-region (Pott et al., 2011). According to Soares and Oliveira (2009) *A. hypogynus* was second in density and frequency in two of three *T. aurea* savanna areas analysed. The success of *A. hypogynus* may be attributed to its occurrence in different microhabitats, while its maintenance throughout the year is due to the high physiological and morphological plasticity which makes it tolerant to either flooding or drought (Junk et al., 2006; Rebellato et al., 2012).

Table 3. (be continued).

Species	Methodology					
	Line			Plot		
	CR	FR	VIh	CR	FR	VIh
Ludwigia octovalvis	0.55	1.25	2.50	0.21	7.19	7.40
Ludwigia tomentosa				0.79	2.23	3.03
Melochia arenosa	0.10	0.24	0.48			
Melochia parvifolia	0.05	0.06	0.12			
Melochia simplex	1.61	2.98	5.96	2.32	0.37	2.70
Merremia umbellata	1.45	3.28	6.56	0.79	0.12	0.92
Mimosa pigra				0.49	3.84	4.33
Panicum dichotomiflorum	0.05	0.12	0.24			
Panicum laxum	0.11	0.18	0.36			
Paspalum hydrophylum	0.10	0.42	0.83			
Paspalum pontanalis	4.94	1.79	3.58	3.73	1.61	5.35
Paullinia pinnata	1.97	3.04	6.08	1.39	0.62	2.02
Pavonia angustifolia	0.01	0.06	0.12			
Pennisetum nervosum	0.14	0.12	0.24			
Pfaffia glomerata	0.26	1.07	2.15	2.22	5.20	7.43
Phyllanthus amarus				2.22	5.20	7.43
Phyllanthus stipulatus	0.50	2.09	4.17	0.03	1.73	1.77
Pontederia cordata				1.77	2.11	3.88
Pontederia subovata	2.38	4.11	8.23	2.16	0.25	2.42
Prestonia coallita	0.12	0.30	0.60			
Psidium kennedyanum Morong				0.09	1.49	1.58
Psychotria carthagenensis	0.03	0.12	0.24			
Reimarochloa acuta	0.10	0.48	0.95	0.02	0.12	0.15
Sapium haematospermum	0.04	0.12	0.24			
Sapium longifolium	0.22	0.66	1.31	0.09	1.12	1.20
Schizachyrium microstachyum	3.15	3.64	7.27	0.13	0.12	0.26
Scleria microcarpa	2.29	4.41	8.83	0.51	0.25	0.76
Sebastiania hispida	11.46	12.34	24.69	10.87	0.12	11.04
Setaria parviflora	1.37	0.83	1.67	0.60	1.61	2.21
Sida cerradoensis				0.35	11.52	11.88
Sorghastrum setosum	0.09	0.06	0.12			
Spermacoceodes glabrum	0.57	2.21	4.41			
Staelia thymoides	0.03	0.12	0.24			
Steinchisma laxum	1.52	1.67	3.34	8.85	0.50	9.38
Stylosanthes capitata	0.05	0.24	0.48			
Tabebuia aurea	0.70	0.60	1.19	0.18	0.25	0.43
Teramnus volubilis				0.31	0.74	1.05
Thevetia bicornuta	0.06	0.18	0.36	0.26	6.20	6.46
Vigna longifolia	0.26	0.66	1.31			
Wedelia brachycarpa	0.00	0.06	0.12	3.40	0.37	3.78

The high importance values for bare area is caused by a dry period and much of the dead matter comes from species established there, and were undergoing a succession stage after flooding. Still, according to Junk et al. (1989), the maintenance of an initial state of succession in the floodplain, as a result of constant renovation through the flood pulse, promotes the high productivity. The presence of bare ground and/or dead matter promotes soil moisture, and thus allows survival for several weeks of some aquatic species, as previously described. These aquatic species considered, together with annual species, form the temporary species and their occurrence and importance depends on time of observation and collection. Such a process is also related to the seed bank, indicating an extremely important

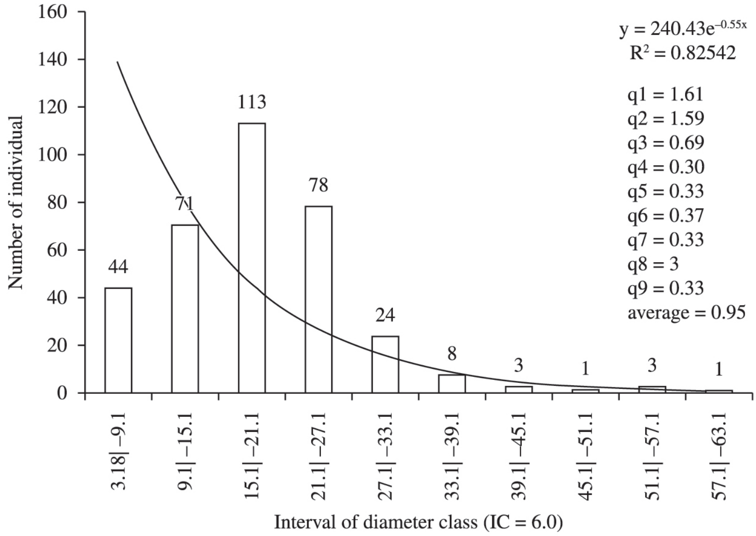

Figure 3. Frequency distribution of diameters (DBH) of individuals of *Tabebuia aurea* (Bignoniaceae) and Licourt quotient "q" sampled in a tropical floodable *Tabebuia aurea* monodominant savanna, sub-region of Miranda, Pantanal, Mato Grosso do Sul state, Brazil.

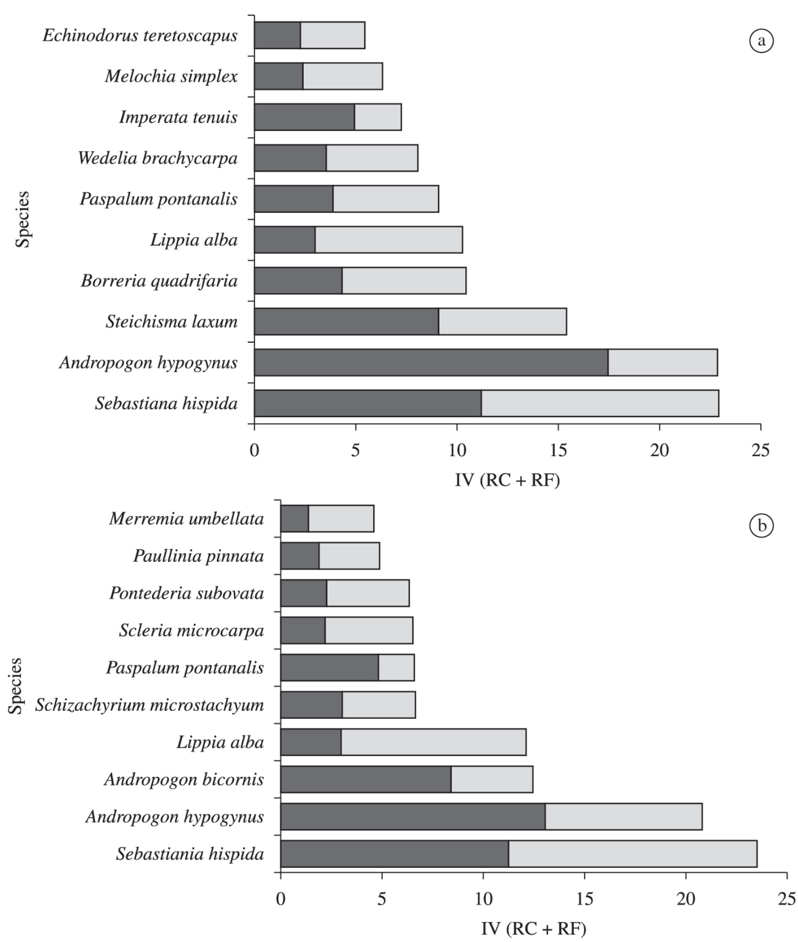

Figure 4. Importance Value (IV) of the ten species most representative by method of plots **(a)** and line interseption method **(b)** in a tropical floodable *Tabebuia aurea* monodominant savanna, sub-region of Miranda, Pantanal, Mato Grosso do Sul state, Brazil. **IV** (Importance Value), **RC** (Relative Cover) and **RF** (Relative Frequency).

role in the resilience of these transitional communities (Brock et al., 2003; Rebellato and Cunha 2005; Junk et al., 2006; Alves Pagotto et al., 2011).

Although there are no data regarding the intensity of human intervention in the area, especially with regard to the effects of grazing and burning, the presence of species considered ruderal such as *Melochia arenosa*, *M. parvifolia*, *M. simplex*, *Sida cerradoensis*, could contribute to elevate the species richness.

4.3. Comparison of methods

We recorded in both methods dominance of the same species of the herbaceous stratum, *Sebastiania hispida* and *Andropogon hypogynus*, which influence the richness and diversity values recorded. There was 59.8% of Sorensen similarity between methods, indicating strong floristic relationship. According to Felfili et al. (2001), Sørensen indices over 50% indicate elevated similarity between two areas. Munhoz and Felfili (2007) reported similar similarity values when analysing the floodplain grassland by the method of linear interception, correlating their result with edaphic homogeneity.

The line interception method was sensitive in the detection of the diversity. That is probably because it allows the equivalent of larger areas to be evaluated linearly. This method is equivalent to using a long narrow plot. As already discussed in the literature (see Condit et al., 1996), there is a higher probability of sampling more species along the line, because it is possible to sample a higher number of microhabitats. On the other hand, plots are better for trees, giving a more precise idea of community structure as a whole. It is, however, possible to survey trees by the line intersection method; however, this was not used in our study because of the low arboreal density.

5. Conclusion

In spite of being a monodominant formation of *Tabebuia aurea*, the vegetation has significant richness with a total of 88 species recorded, when herbaceous stratum is taken into account. Of the employed methods, plots have the advantage of integrating the data on tree and on ground vegetation, thus allowing a more detailed analysis, however, the method of line interception is better in detecting species richness.

Flooding is a selective factor in occurrence species in both tree and ground strata, and thus influences richness and diversity. However, there is a need for continuous monitoring of the area so that one can understand successional changes of this vegetation type relative the to flood pulse, as well as anthropic processes such as grazing and fire.

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